Work-in-Progress: Design of an Online Learning Coach

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Abstract

We have designed The Learning Coach (TLC) to be a hybrid online system that can supplement traditional instruction. Via a ground-up implementation, our effort is a joint process addressing both user interface features and instructional pedagogy. This paper describes the design, which was based on a review of best teaching practices. TLC includes embedded pre- and posttests, active learning exercises and homework problems. These features are integrated within TLC and are accessed sequentially via a defined lesson plan. The design also provides individualized content. Lesson module recommendations that based on pretests, examine both knowledge and confidence in material. Users may then adjust the suggested coverage before starting a lesson. Our goal for customizing instruction is to identify both gaps in knowledge and students’ misconceptions (i.e. knowledge that students believe they have mastered, but that is actually faulty). Via this paper we would like to engage educators and developers of online learning tools to contribute suggestions towards the further refinement of our system. Upcoming in this effort will be test trials with students and faculty to examine the effectiveness of various features.

Goals for TLC

Hybrid learning systems span a wide variety of instructional modes, and provide varying amounts of integration with traditional courses. One means to differentiate hybrids is by the degree of integration (if any). Integration may be in the form of either a tight or loose coupling, relative to the timing of instruction in the face-to-face component. For example a flipped course might employ online learning in a tightly coupled fashion, with students receiving their initial instruction on a topic via the online source. Flipped courses then permit face-to-face time to be used for more individualized instruction. Other hybrid methods are more loosely coupled to a traditional lecture. In these cases, online content might serve as a supplemental information source, with timing determined by a student’s interest. Posting material to a learning management system is an example of this type of approach. Massively Open Online Courses (MOOCs) are another variant, which may eliminate face-to-face instruction. Online industrial training systems are also in this category.

Our intention for The Learning Coach (TLC) is to create a hybrid with some flexibility, and able to serve as either a primary or supplemental source of content. For example, students might use TLC for the initial introduction to course topics, or as a means of review before an exam. Furthermore we aim to develop a system that can support varying degrees of coupling with a traditional course. This flexibility can help an instructor as well as the student. For example, it could allow an instructor to transition from a loosely coupled mode to a more tightly coupled mode, overtime, in a given course.
When used in conjunction with a traditional course, we envision TLC as providing supplemental instruction for students outside of lecture. We are designing TLC to help students catch up on material, get reinforcement, or fill in gaps in their abilities. It could also be used as a primary source for first-time instruction, but this is not our main goal. As an example of where TLC might be helpful, consider an engineering science course with a large lecture that is given to many non-majors. The students in such a course may have widely varying aptitudes and motivation levels. Their grasp of prerequisite material may also differ significantly. Furthermore if one-on-one or small format (recitation sessions) are not available, then some students may perform more poorly without additional guidance. This is a situation in which TLC might benefit student learning.

Why Should We Care?

Universities that are struggling to afford hands-on, laboratory-intensive curricula or project-based research experiences may find it necessary one day to employ online approaches to reduce lecture costs. Employing online methods may help preserve these other high-cost, high-value, experiences for students. Thus despite a certain frenzy over MOOCs and related systems today, this may not be a fad. We may continue to see a shift to online partnerships.

Furthermore, online methods can provide more opportunities than simply shifting the delivery mode of an individual course. For example, consider the just-in-time online delivery of course prerequisite material. Students could learn prerequisite material (or a portion of it) interleaved with material during a subsequent course. This would help underscore relevance of the prerequisite course. It would also permit material to be revisited with increasing levels of sophistication, as suggested by Sheppard. An integrated delivery such as this could help restructure a curriculum by breaking down traditional course and departmental walls. Cross-course, cross-departmental and cross-institutional partnerships can all be enabled by online means.

Joint Design Process

In the sections that follow, we consider both user interface features as well as pedagogical approaches to instructional design for TLC. Because our implementation is being developed from the ground-up, we have the freedom to specify both of these areas. Following a discussion of the major design elements we identify some future research questions.

As is typical, our real design process was far from a linear. The actual process included the usual twists and turns: eliminating options, considering nearest neighbors, clarifying requirements and discovering new perspectives. Nevertheless, we present the design features in a systematic fashion including a series of Design Overviews that describe stepwise refinements, as if part of a linear process. At each stage of the design process we consider best practices and cite specific approaches for TLC. The design overviews present more general summaries of our approach at each stage. Our initial overview is based solely on the goals for TLC.
Design Overview 1

Hybrid, individualized content

Across the wide variety of online learning systems, hybrids that partner with traditional courses have been shown to be superior over either extreme of purely online or purely face-to-face approaches\(^2\). Thus the goal of a hybrid system appears to have merit. We now turn to more specific design considerations.
Design Considerations: Leverage Best Practices

Chickering and Gamson\textsuperscript{1} identify broad goals for instruction in their *Seven Principles for Good Practice in Undergraduate Education*. See Table 1. Their principles suggest both user interface features as well as some pedagogical elements for the instructional design.

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Design Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourages contact between students and faculty</td>
<td>Hybrid/flipped course increases the amount of available face-to-face time. Students may be more willing to meet with a (non judgmental) online learning coach, in preparation for a meeting directly with a faculty member?</td>
</tr>
<tr>
<td>Develops reciprocity and cooperation among students</td>
<td>Forums may encourage student-to-student interactions</td>
</tr>
<tr>
<td>Encourages active learning. Gives prompt feedback.</td>
<td>Engage students with interactive exercises, providing immediate feedback</td>
</tr>
<tr>
<td>Emphasizes time on task</td>
<td>Adjust content for each user, attempting to maximize effective use of student’s time.</td>
</tr>
<tr>
<td>Communicates high expectations</td>
<td>Present results of student performance explicitly in terms of each learning objective. Set the bar high when describing expectations for student performance.</td>
</tr>
<tr>
<td>Respects diverse talents and ways of learning</td>
<td>Provide individualized instruction for users</td>
</tr>
</tbody>
</table>

**Table 1. Recommendations of good practices by Chickering and Gamson, with some pursuant design considerations**

It may be counterintuitive that an online tool would encourage contact between students and faculty. (See first row of Table 1). Nevertheless online methods providing a flipped classroom environment, can improve provide the effectiveness of available face-to-face time\textsuperscript{3}. Thus contact between students and faculty can improve by employing a hybrid tool. Also if the hybrid can help a student formulate questions or bound uncertainties, then it may foster better students / faculty exchanges.

A forum type of venue could provide a useful means to engage students with open-ended types of questions. For example, students could be asked, “How might you address a given situation (method A vs B) and why do you prefer this approach?” or asked, “What did you learn of significance in the prior example?” Students would then have the opportunity submit a contribution, to view other submissions and to like/dislike these entries. Opportunities to share ideas; to share difficulties, problems and solutions; and to feel that others have similar experiences can all build confidence, according to results from Eldred\textsuperscript{8}.

**Design Overview 2**

*Hybrid, individualized content, forums, and interactive exercises with feedback*

Design Considerations: Encouraging a Deep Approach to Learning
Felder describes a student with a deep approach to learning as one who seeks underlying meanings and connections to other knowledge and methods. Students employing a deep approach avoid simply memorizing facts. And they are typically motivated by intellectual curiosity, as opposed to the reward of a good grade. Ramsden showed the benefits of a deep approach include better comprehension, integration and interpretation. The deep approach also fostered longer retention and higher grades.

Felder summarizes some approaches to classroom instruction that encourage students to adopt a deep approach, as given in Table 2.

<table>
<thead>
<tr>
<th>Recommendations</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Interest in and background knowledge of the subject</td>
<td>Emphasize usefulness of subject material explicitly</td>
</tr>
<tr>
<td>Clearly stated expectations and clear feedback on progress</td>
<td>Identify learning objectives and establish clear links to course content and assessments</td>
</tr>
<tr>
<td>Assessment methods that emphasize conceptual understanding</td>
<td>Include concept-oriented questions in the embedded online assessments</td>
</tr>
<tr>
<td>Teaching methods that foster active and long-term engagement with learning tasks</td>
<td>Engage students via active learning exercises that are embedded within online content</td>
</tr>
<tr>
<td>Opportunities for students to exercise responsible choice in the content and method of study</td>
<td>Provide content that is individualized via recommendations that a student can adjust</td>
</tr>
</tbody>
</table>

Table 2. Recommendations by Felder to encourage a deep approach to learning on the part of students, and related design considerations

Comparing Table 1 and Table 2, we see consistent recommendations for active learning. Furthermore, Felder & Brent speculate that instructional settings, which provide a variety and choice of learning tasks and provide a student-centered instructional environment, will help promote intellectual development. Our interest in individualized instruction stems from the goal of supporting students at different stages in their learning. Now beyond that, we see the potential for additional benefits via this flexibility, based on efforts by Felder & Brent.

**Design Overview 3**

*Hybrid, individualized content, forums, interactive exercises with feedback, content includes: motivation & concepts, and explicit use of learning objectives*

**Design Considerations: Teaching Through the Kolb/4MAT Learning Cycle**

Kolb’s model of learning styles provides a basis for the 4MAT approach to instruction. Harb describes this model of learning as a process that traverses four quadrants of a plane. In this paradigm, the learning process for a student should strive to consider a series of questions: Why? What? How? and What if?
According to Harb, there are two primary motivations to employ the Kolb/4MAT method. First, it provides a means to align instruction with the full spectrum of learning styles\textsuperscript{11}. Second, it promotes life-long learning by providing students with a stepwise framework. When students are exposed to lectures in this framework, Harb suggests that it encourages them to adopt the approach in their own self-directed efforts. See Table 3. We include the Kolb/4MAT framework to provide additional structure to the online presentation of materials in TLC.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Why? Teacher’s Role: Motivator</td>
<td>Identify explicit connections to past and future topics. Provide specific examples of problems a student could not solve (as easily) without current topic.</td>
</tr>
<tr>
<td>What? Teacher’s Role: Expert</td>
<td>Core instruction including examples that are lead stepwise. Simple examples of problem solving using techniques, requiring simple calculations at most.</td>
</tr>
<tr>
<td>How? Teacher’s Role: Coach</td>
<td>Embedded interactive ‘examples’ that are guided in small steps. No time limits for students when working on problems. Embedded ‘homework’ in which students apply information. Homework is not guided in a stepwise fashion, but hints may be provided for critical steps. Establish TLC as a safe learning environment.</td>
</tr>
<tr>
<td>What if? Teacher’s Role: Lead students on process of self-discovery</td>
<td>Query students on tactics that they may use when tackling a problem, provide feedback on relative merits of methods chosen. Ask students to identify an application of course topics, to reflect on relative merits of a technique, to create an analogy to another discipline, to consider results for an extreme case or extreme choice of parameters, or to generalize relationships from specific cases. Ask students to identify any watershed moments in their learning (via a forum). Use a forum permitting students to share ideas, to see ideas from others, and to comment.</td>
</tr>
</tbody>
</table>

Table 3. Recommendations from the Kolb/4MAT approach to guide students through a process considering questions: Why? What? How? And What if?

The Kolb/4MAT approach sheds a new light on the coaching paradigm – the notion that TLC should provide a safe learning environment. This is entirely consistent with a hybrid mode, and consistent with Chickering and Gamson\textsuperscript{1}. Compared to a traditional course, an environment in which learning occurs in a more private setting and decoupled from course grades might seem less intimidating, and thus safer, for some students. This may help encourage adoption of TLC by students.

**Design Overview 4**

Hybrid, individualized content, forums, interactive exercises with feedback, content includes: motivation, concepts, strategy, examples & homework, explicit use of learning objectives, opportunities for self-reflection and providing a safe learning environment
**Design Approach: Individualize Content via Pretests**

Customizing the presentation of material for a student has been cited as both a best educational practice\(^1\) and as a means to encourage a deep approach to learning\(^9\). A simplistic approach to individualize content might be to omit content modules that a student has already mastered. This could be done via the pretest and it could improve the quality of time spent studying.

However providing individualized content can also play a much more significant role. Taylor documented significant impediments to the learning process when students harbor preconceived misconceptions about course topics\(^{14}\). Given our interest in accommodating students at various stages in their learning, the identification (and eventual correction) of these misconceptions is an important function for TLC.

To help flag the severity of misconceptions, our design incorporates a confidence measure, in which users explicitly describe the certainty of their answers in a pretest. Taylor\(^{14}\) and Bruno\(^{15}\) describe methods that use implicit methods to estimate student’s confidence in material while simultaneously examining their performance. These approaches are attractive, however a patent has been issued (US #6,921,268) related to the implicit methods. Hence we are pursuing an explicit confidence declaration for TLC, to avoid conflict.

In the pretest a user’s ability and confidence for each learning objective associated with an instructional module will be examined. A user’s knowledge of the motivations for a topic will also be examined in the pretest. See Figure 1. Questions are multiple-choice, but users can select more than one answer as possibly being true. Users then press the +/- buttons to indicate their confidence in each response. (Students who are new to the content of a given section may alternatively skip the pretest).

Based on the results of the pretest, certain learning objectives will be recommended to the user. Recommendations will be automatically computed based on both the user’s self-declaration of confidence as well as their performance on pretest questions. The most critical recommendations will follow from learning objectives associated with high confidence and low performance.

Before proceeding into a lesson, users may adjust recommendations stemming from the pretest. A lesson then advances through relevant sections. Navigation through lesson content, based on chosen learning objectives, is achieved by a mechanism similar to the feature allowing users to peruse content by a search on learning objectives. During the instructional design, instructors are prompted to identify learning objectives for each major subsection in order to enable both the search and content customization.
Figure 1. Design for TLC pretest, which checks knowledge and abilities, as well as students’ confidence. Levels of confidence are explicitly declared using the +/- buttons and displayed on bar graphs.

Design of TLC Student Interface

Our overall design includes both user interface features and recommended best practices for instructors to use when creating TLC courses. To encourage best practices, we envision a template, or wizard, that guides instructors through the definition of a course module (see next section).

Figure 2 illustrates a number of user interface features. Students will hear a recorded voice over slides, images or derivations. Highlights and progressive disclosure help focus a student’s attention. Navigational features include a hierarchical table of contents (on the left side). Learning objectives, keywords, and the Kolb/4MAT learning stage appear in text boxes in the lower portion. Users may search based on each of these criteria.

To engage users during lecture portions and to provide a mechanism for both exercises and homework, we have a variety of question and answer modes. Multiple choice and check box types are included, with automatic grading and feedback. See Figures 3 and 4.
Figure 2. Design for the basic layout. A hierarchical table of contents appears to the left. Keywords, learning objectives and learning stage appear in the lower portion.

Figure 3. Design for an embedded multiple-choice question.
Design Concepts for TLC Instructional Module

To help instantiate the best practices cited previously, instructors will be prompted for recommended content as they develop a TLC course. Prompting would help an instructor remember to include various types of content and would promote an efficient instructional design process. A possible template for a generic TLC instructional module follows. This example template is geared towards an engineering science course.

1. Statement of learning objectives
2. Pretest addressing each learning objective, and motivation for the new topic
3. Review and adjustment of recommendations for topic coverage (based on result of pretest on learning objectives with confidence declarations).
4. Content – Why?
   a. Describe motivations for the new topic
      i. Describe a problem that is difficult to answer without new topic
      ii. Describe an application enabled thanks to the new topic, and importance / societal impact of application
   b. Include historical context or fun facts
5. Content – What?
   a. Present overview
   b. Present details: derive and describe concept, process, technique, analysis or method
   c. Engage students via simple Q&A, with feedback, to keep students involved in the flow of the presentation
      i. Questions may illustrate concepts or reinforce key steps
6. Content – How?
   a. Present comprehensive aspects of topic, repeat overview
   b. Engage students via more involved Q&A with feedback\textsuperscript{1,10}
      i. Questions may require several steps on the part of the student, synthesizing concepts and abilities.
   c. Engage students via forums or FAQs with like/dislike rankings, asking students:
      i. Reflect on any watershed moments during lesson\textsuperscript{8}

7. Content – What If?
   a. Present comparative aspects of topic:
      i. Strengths, weaknesses, options, variations, extensions
      ii. Relationships to other topics\textsuperscript{9,13}
      iii. Prioritize importance of various aspects of topic\textsuperscript{16}
   b. Engage students via forums with like/dislike rankings, asking students to:
      i. Suggest a real-world application of a concept\textsuperscript{11,13}
      ii. Suggest an analogy to a concept\textsuperscript{11}
      iii. Given a hypothetical case, identify an approach and why\textsuperscript{8,13,16}

8. Posttest, similar to style pretest
9. Review of changes in user’s performance and confidence pre->posttest
10. Set high expectations for performance – push comfort zone\textsuperscript{1,16}
   a. Best: Capable in areas both in and out of comfort zone
   b. Medium: Capable in comfort zone, less strong with an alternate approach
   c. Weaker: Struggling to reach a comfort zone
11. Summative homework, follow-on assessment
   a. Questions may require several steps on the part of the student, synthesizing concepts and abilities.
   b. Approach for a given problem is up to student to determine
   c. Homework problems can include hints
   d. Homework automatically graded with feedback

Next Steps – Initial Deployment and Design Revision

Next major step on this project is to establish the content for some lesson modules and test various design features suggested in this paper. We plan to engage faculty and students in these evaluations. We welcome input from other developers of on-line systems.

A key feature of TLC is the pretest mechanism for individualizing content. We are curious if students use the pretests and posttests, and to what degree these benefit student learning. A common benchmark for students using, or not using, the pretests is the summative homework (section 11 of the template, above). Thus we can compare the benefit of individualized content via the summative homework. We can also examine these results across various demographic groups of users.

We are also curious about the usage and benefit of active learning exercises that are embedded in lectures (section 5.c of the template). The Q&A for active learning is meant
primarily to maintain engagement of students during a lesson. Thus we imagine that these questions will be relatively easy and straightforward, to reinforce specific concepts. Hence we would expect a high percentage of correct answers with the active learning exercises, if users take them seriously. We are curious regarding the potential benefit of active learning exercises towards improving summative homework. These benefits should be examined for various demographic groups. Similarly, the usage of forums and FAQs should also be examined to determine the amount of use and benefit.

Furthermore, regarding forums, our observations of some MOOCs are that the forum submissions may often relate to mechanics of using the system, or to various gripes. Thus it appears that forum submissions are not always germane to the course topic. Encouraging the relevance of forum submissions may be an important follow-on study.

We plan to query new users regarding their background, in order to establish various demographic groups. Our working assumption is that we should distinguish between various users based on their background and experience in order to establish relevant demographic groups. For example, distinguishing between industry practitioners versus college students, and between those with a major (or degree) in a field related to the course content or not. Furthermore the user’s intention in taking the course may be a helpful distinguishing characteristic as well. For example, is a user taking a course for review, to reinforce existing skills; or is a user taking the course to develop new skills? These demographic categories may also be useful for tagging and filtering user submissions to a forum or FAQ list. Demographic tags would allow users to see entries by others with similar backgrounds, or to simply see all available. This will be an ongoing area of investigation and development.

As TLC is intended to enable a hybrid environment to compliment traditional instruction, we plan a survey to investigate the benefits of this partnership. We are curious about the different ways that students may use TLC within a course (for example, when reviewing for an exam). Open-ended questions may help identify strengths and weaknesses. Might users describe TLC as a safe environment? Following some of these preliminary investigations we also want to examine the benefit of TLC on students’ course grades.

We summarize our initial questions regarding TLC features as:

• Will students use the pretests and posttests? To what degree do these benefit student learning?
• Will students take the time to respond thoughtfully / correctly to the embedded active learning exercises, or will they attempt to move through the material as quickly as possible?
• How can we encourage students to use embedded discussion forums and FAQs, and to provide thoughtful input?
• How do the above questions vary by demographic groups?
• How might students use TLC within the context of a traditional course?
• At present TLC does not support ‘study buddy’ teams. Should it?
Summary

We have designed The Learning Coach to be a hybrid online system, intended to supplement traditional instruction. TLC includes embedded active learning exercises and homework problems. To support a wide range of users with differing abilities, TLC is designed to provide individualized content. Recommendations for content coverage will be provided via a pretest, and users will then be able to adjust these suggestions. Pretest recommendations examine both content knowledge and declarations of confidence given by the user. Comparing to some mainstream MOOCs, TLC is closest to Udacity and edX, except these other systems do not provide individualized content.5,6

TLC is similar to Udacity and edX in that each provides the means to integrate varied types of content together for a sequential presentation to the user. For example, lecture content can be interspersed with active learning exercises. Homework style questions can follow lecture, and be automatically graded. Hence these systems are quite different than a Content Management System such as Moodle17 because the varied types of content are not presented in a sequential fashion. As an analogy this would be the difference between a standard book versus one in which the pages are cut out a spread across a table. With loose pages there is no control over the order the sequence of the presentation. Furthermore, TLC, Udacity and edX limit the user’s ability jump ahead. Rather knowledge checks, pretests, and posttests can be performed with feedback before allowing a user to advance.

Although this paper focuses on design aspects, we should also mention that the system is implemented as a Java application18. A custom implementation was needed in order to integrate various features of TLC. Java provides mainstream platform with a rich native environment to support varied media, along with sizeable contributions from 3rd party developers.

Via this paper we would like to engage students, educators, and developers of online learning tools, to collaborate on further refinements to TLC. We thank the reviewers of this paper for their helpful suggestions.

Bibliography


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[18] www.java.com